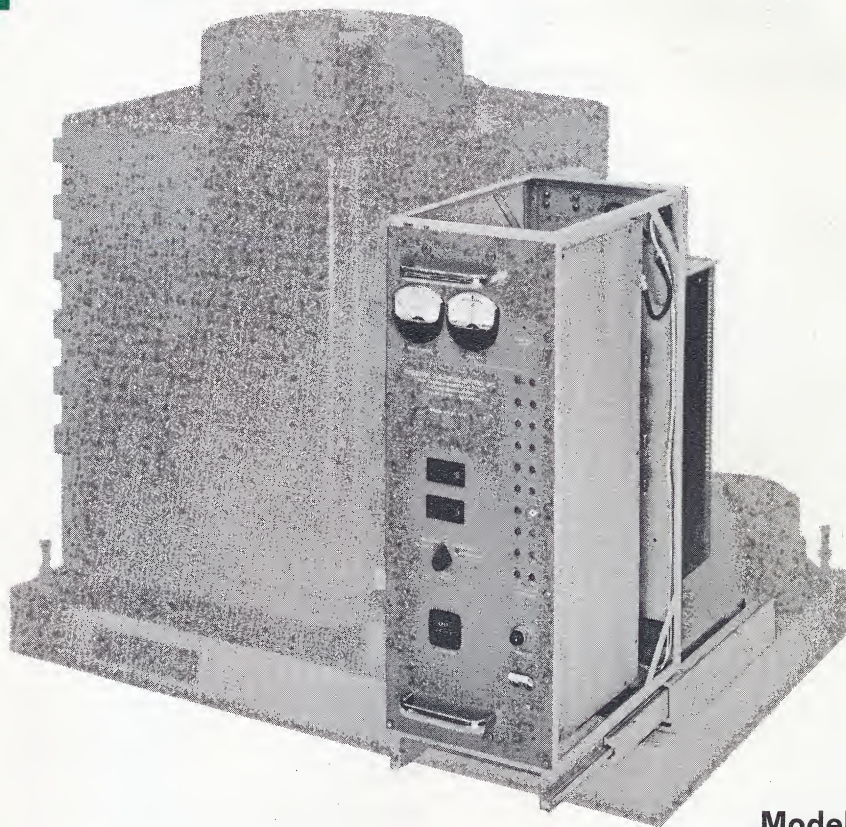


SEQUENTIAL ELECTRONIC SYSTEMS

MAGNETIC DRUM SYNCHRONIZATION SYSTEM

FEATURES

- Time displacement error less than 100 ns
- Unlimited number of drums can be electronically geared to perform as a single unit
- Non-volatile storage
- Absolute position control of all drums under all conditions i.e. even after power failure
- No trim adjustments
- Increases storage capacity of alpha-numeric display systems or digital computers on a modular basis
- Integrated circuit electronic assemblies available for airborne applications
- Projected electronics MTBF greater than 15,000 hours
- Meets all applicable MIL-SPECS



**Model
DS12**

INTRODUCTION

The Sequential Magnetic Drum Synchronization System Model DS12 electronically gears any number of individual drums with a time displacement error (TDE) of less than 0.2 microseconds between any two arbitrary drums. Prior state-of-the-art required that a reference track on a single drum determine the clock rate of a digital computer or display system. Lack of precision drum synchronism, thereby restricted a computer or display to limited storage access obtainable by a single drum.

The technique employed by Sequential couples individual drums by means of an external reference frequency. This reference is utilized as the clock frequency for the computer or display system. Therefore, a flexible modular approach to present memory storage problems is now available. The storage capacity of a system can be increased, without limit, by the addition of any number of controlled drums.

OPERATION

The Sequential Drum Synchronization System Model DS12 may be described in terms of four (4) interacting control functions. These functions are:

- a) The primary speed/phase control as implemented by an FPL SPEED/PHASE CONTROL LOOP.
- b) A phase correction control as implemented by the PHASE CORRECTION LOOP.
- c) A reference generator control as implemented by the REFERENCE GENERATOR LOOP.
- d) An indexing control as implemented by the INDEXING LOOP.

Figure 2 is the System Block Diagram. This figure indicates the four (4) broad functional control loops. Figure 3 presents a functional block diagram of the system. In this block diagram each of the major blocks of Figure 1 have been broken down into several functional components.

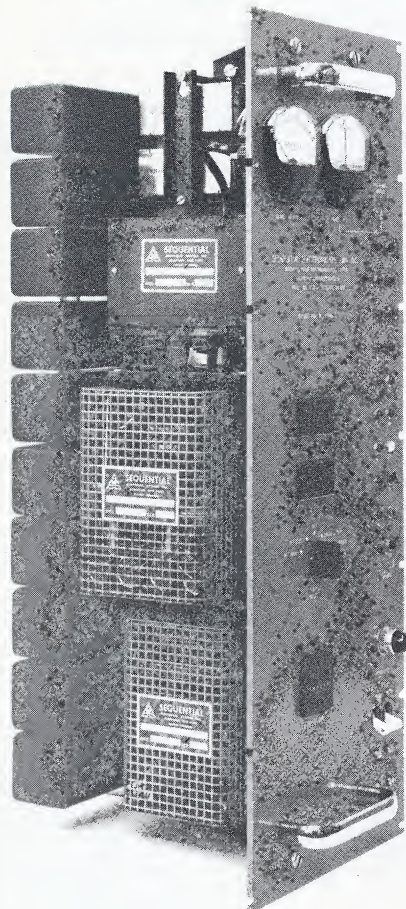


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66 Saw Mill River Road, Elmsford, New York (914) LYric 2-5810 TWX 914 582 6368



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INPUT SIGNAL FUNCTIONS

A. Reference Clock Signal

The Reference Clock Signal is a timing pulse train whose leading edge generates incremental position commands to the drum, and whose frequency generates precise speed commands. The drum speed is directly proportional to the Reference Clock Signal frequency. If the Reference Clock Signal frequency is lowered, the drum will decrease in speed. If the Reference Clock signal frequency is increased, the drum will increase in speed.

B. Reference Index Signal

The Reference Index Signal is a command index pulse whose leading edge is aligned with a leading edge of one of the Reference Clock Signal pulses. The Index Signal repeats once per drum revolution. If the Reference Index Signal is removed, after the drum has achieved index synchronism, the drum will maintain index synchronism unless a disturbance occurs to shift the drum position by more than one bit spacing within the index slot.

C. Drum Clock Signal

The Drum Clock Signal is the high frequency (N pulses/rev) feedback control signal and is electromagnetically derived from a track on the drum.

D. Drum Index Signal

The Drum Index Signal is the once/rev feedback control signal and is electromagnetically derived from a track on the drum. This Index pulse is centrally located between two Drum Clock Signal pulses.

DUAL READ AMPLIFIER

The Dual Read Amplifier is used to shape and amplify the Drum Clock signal and the Drum Index signal. Figure 3 shows the input and output characteristics of the Dual Read Amplifier.

FPL SPEED/PHASE CONTROL LOOP

The Speed/Phase Control Loop utilizes as its inputs a reference pulse train that is generated by the Reference Generator Loop and the Phase Correction Loop, and a feedback pulse train that is derived from the Dual Read Amplifier.

This speed/phase loop locks the drum clock frequency to the incremental reference. The incremental reference

and the drum clock signals are compared on a frequency/phase basis in the FPL* Computer Module which generates an error signal accordingly. The magnitude and polarity of the frequency error is such, that when converted to d.c., amplified, and passed to the brake driver, the drum is forced to rotate at a speed at which the clock pulse frequency equals the reference frequency.

To maintain precise synchronization, a phase error signal is generated once the drum has achieved synchronism. The phase error signal controls the brake excitation to maintain "tight" phase alignment between the reference pulse train and the feedback signal, when frequency-lock has been achieved.

The unique feature of the FPL Computer is that the frequency lock and phase lock logic operate simultaneously, and the transition from the frequency control mode to the phase control mode is automatically performed in a continuous manner, so that no switching signals or transients appear in the error signal.

The phase error information produced by the computer is in the form of relative pulse spacing between the reference and tachometer signals.

The function of the D/A CONVERTER MODULE is to convert the above relative pulse spacing (phase error) information into a d.c. signal proportional to the phase error. This conversion is performed on a pulse-to-pulse basis, with no significant time constant, and with virtually no ripple. The electrical bandwidth is one-half the frequency of the reference signal, which permits design of an extremely wideband and high gain control loop.

The STABILIZATION MODULE contains circuitry which applies phase, velocity, and acceleration control in the proper ratio, and with proper frequency characteristics, so as to optimize the closed loop performance of the control loop. This module also contains circuitry associated with the Brake Driver Assembly.

The BRAKE DRIVER ASSEMBLY supplies correct excitation to the Brake windings to maintain precise drum synchronism. Excitation signals from the Driver are fed back to the Stabilization Module, so that the driver and brake windings are operated in a secondary closed loop manner. The effect of this type of operation is to linearize the torque output characteristics, and to virtually eliminate the electrical inductive time constant of the brake windings.

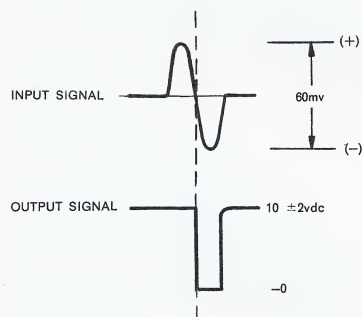


Figure 1—Dual Read Amplifier Signal Characteristics

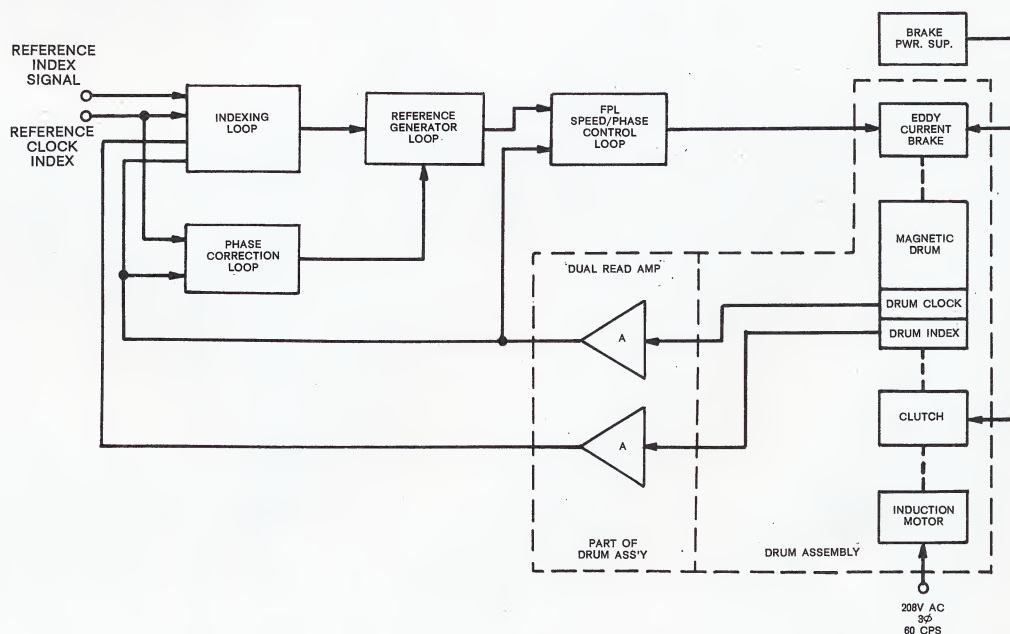


Figure 2—System Block Diagram: Sequential MDSS* Control and Indexing System Model No. DS12

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If a torque disturbance is applied to the drum the phase angle between the reference and feedback signals will shift changing the phase error signal. The torque output of the brake will change by an amount which will just cancel the torque disturbance and maintain speed synchronization. In closed loop operation, the maximum electrical phase shift is limited to $360/K_p$ degrees, where K_p is the electrical phase-lock gain. Since the drum clock produces N pulses/revolution, $360/K_p$ electrical degrees corresponds to $360/NK_p$ mechanical degrees. The mechanical incremental phase locking of the drum is therefore a function of the Drum Clock pulse density (N), and the electrical phase-lock gain (K_p).

As in any mechanical structure, there will be certain torsional structural resonances of the mechanical load; therefore necessary bandwidth cutoff filters are incorporated within the stabilization module. These cutoff filters insure that loop gains at and beyond resonance frequencies are sufficiently attenuated so as to not reinforce or trigger structural resonances.

The control loop is a hybrid type of instrumentation with digital error sensing and analog stabilization parameters. This mechanization fulfills the necessary conditions of both high accuracy and superior dynamic performance.

REFERENCE GENERATOR LOOP

The Reference Generator Loop may be considered as a function generator, which receives either of the following signals:

- The true Reference Clock signal if the Index Slot is at the proper index position with respect to the Reference Index.
- A Positive Shift Reference Signal proportional to the phase lag of the Index Slot relative to the Reference Index.
- A Negative Shift Reference Signal proportional to the phase lead of the Index Slot relative to the Reference Index.

To maintain a constant but adjustable phase relationship between the Reference Clock Signal and the Drum Clock Signal a d.c. control voltage, derived from the Phase Correction Loop is also fed into the Reference Generator Loop. This phase correction is achieved by shifting the leading edge of the Phase Shift Module output signal in the proper direction so as to correct for any steady state disturbance in the drum position.

Three (3) modules make up this loop; the Frequency Shift Module, the Frequency Comparator Module, and the Phase Shift Module.

PHASE CORRECTION LOOP

The Phase Correction Loop utilizes as its inputs the Reference Clock Signal and the feedback pulse train or Drum Clock Signal as seen at the output of the Dual Read Amplifier.

The Phase Comparator Module generates a signal whose phase angle is equivalent to the phase error between the Reference Clock Signal and the Drum Clock Signal on a pulse-to-pulse basis.

The Phase Integrator receives a phase error signal from the Phase Comparator Module and converts it to a d.c. signal proportional to phase error. This d.c. signal phase shifts the output of the Reference Generator Loop to force the phase error to a null.

The Phase Null is set at 180 degrees phase shift between the Reference Clock Signal and the Drum Clock Signal.

The Phase Null point may be adjusted with the Phase Null Adjust provided on the instrument panel and may be observed on the Phase Null indicator also provided on the instrument panel. The Phase Null Indicator reads a null for a 180 degree phase shift.

INDEXING LOOP

The Indexing Loop utilizes as its primary inputs the Reference Clock Signal, Reference Index Signal, Drum Clock Signal, and the Drum Index Signal.

The Drum Clock and Drum Index signals are derived from the Dual Read Amplifier.

The Index Gating Module tags a particular index slot which is between the seventh and eighth bit on the Drum Clock Signal with respect to the Reference Index Signal. The index slot is generated from the start of a Drum Index Signal. The actual Drum Index position is at 180 degrees between the seventh and eighth bit on the Drum Clock Signal.

The Index Comparator Module senses and continuously monitors the position of the index point. The gating logic selects and gates through the proper correction signals to the Reference Generator Loop.

*Patent Pending

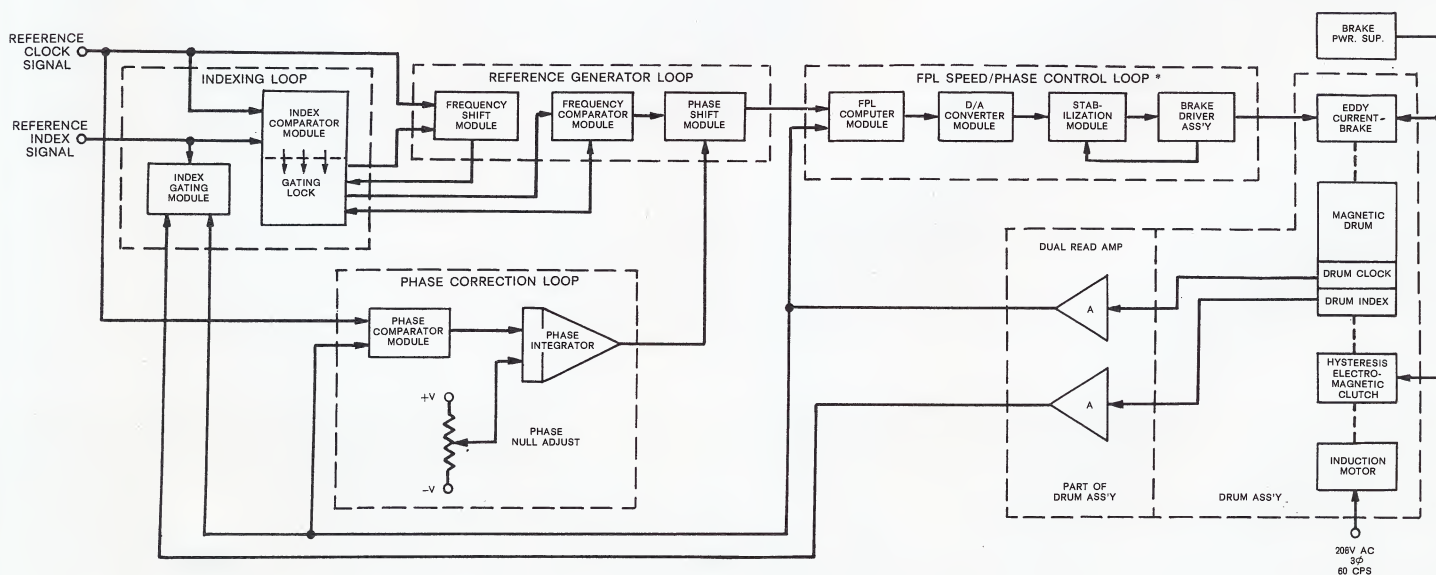
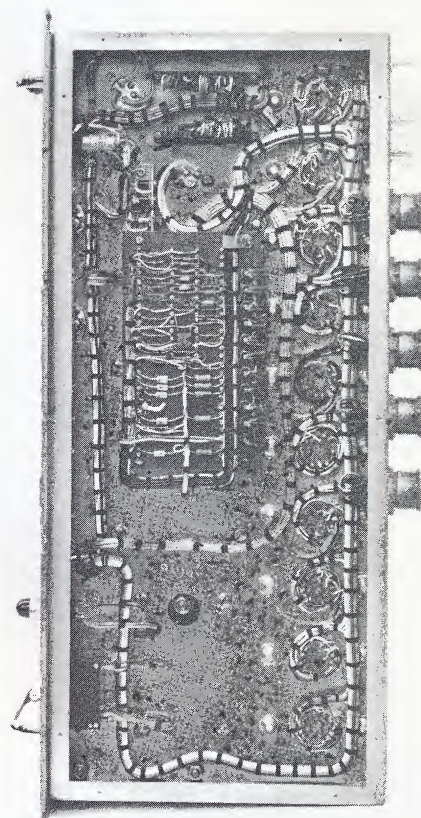
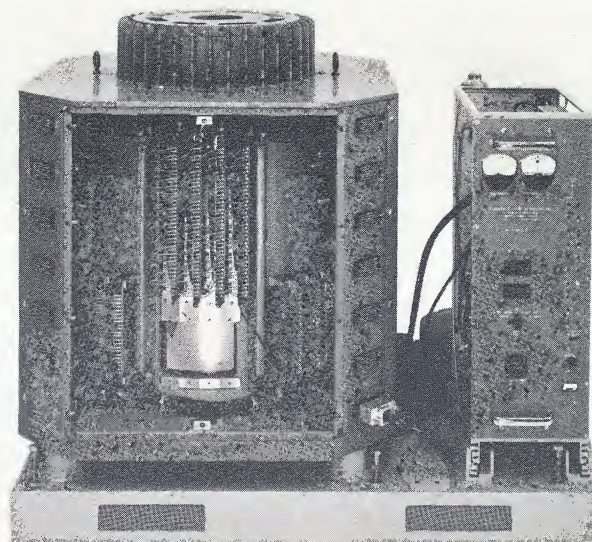


Figure 3 - Functional Block Diagram: Sequential MDSS* Control and Indexing System Model No. DS12

SEQUENTIAL MAGNETIC DRUM SYNCHRONIZATION SYSTEM MODEL DS12

SPECIFICATIONS



Drum Speed (ΩRPM) Specified by customer

Drum Clock Pulse Density (N) Based on Specific application

Reference Signals

Clock Signal

Frequency $f = \frac{\Omega N}{60}$ cps
Waveform Zero Based Position Pulse
Amplitude 2 volts
Base line noise ± 0.15 volts max
Duty Cycle less than 50%
Rise Time 0.15 microseconds max
Source Impedance 600 ohms max

Index Signal

Frequency $f = \frac{\Omega}{60}$ cps
Waveform Zero based positive pulse
Amplitude 2 volts
Base line noise ± 0.15 volts max
Duty cycle less than 50%
Rise time 0.15 microseconds max
Source Impedance 600 ohms max
Phase Alignment Reference Index Pulse must be phase locked (counted down from the clock signal) to the clock signal and aligned with a clock pulse within ± 0.5 microseconds

Drum Signals

Clock Signal

Frequency $f = \frac{\Omega N}{60}$ cps
Waveform essentially sinusoidal pulse
Amplitude 60 mv p-p min
Signal Source Magnetic Head
Signal-to-Noise Ratio 12 db min

Index Signal

Frequency $f = \frac{\Omega}{60}$ cps
Waveform essentially sinusoidal pulse
Amplitude 60 mv p-p min
Signal Source Magnetic Head
Signal-to-Noise ratio 12 db min
Phase Alignment Drum Index Pulse to be located approximately 180 degrees between two clock pulses

Absolute Position Accuracy (Time Displacement Error, TDE)

± 0.1 microseconds non cumulative

Input Power

Voltage 115 volts single phase or 208 volts 3 phase
Frequency 60 cps or 400 cps
Current Based on specific application

Size

Electronic Control Console (1) 9" w x 24" h x 11" d
Brake Power Supply Based on specific application
Dual Read Amplifier 3" w x 3" h x 3/4" d

Temperature Range

Operating 0°C to +60°C
Non-operating -55°C to +71°C

Humidity

97%

Vibration

.005 inches double amplitude from 10 to 55 cps; .005 inches double amplitude from 55-500 cps with a maximum acceleration of 5 g's

Shock

5 g's in any plane, 11 milliseconds duration

Note

1. Miniaturized integrated circuit electronic assembly available



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66 Saw Mill River Road, Elmsford, New York (914) LYric 2-8810 TWX 914 592 8368